PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : C10G 65/12, 69/10

A1

(11) International Publication Number: WO 94/26848

(43) International Publication Date: 24 November 1994 (24.11.94)

(21) International Application Number: PCT/KR94/00046

(22) International Filing Date: 16 May 1994 (16.05.94)

(30) Priority Data:

1993/8408	17 May 1993 (17.05.93)	KR
1993/27373	11 December 1993 (11.12.93)	KR

(81) Designated States: AT, AU, BG, BR, CA, CN, CZ, DE, ES, FI, GB, HU, JP, NL, NO, PL, RO, RU, UA, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

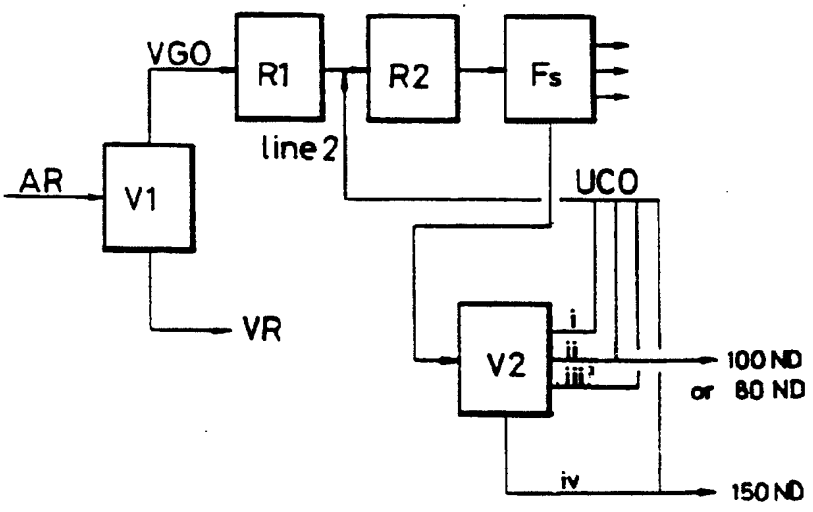
Published
With international search report.

(71) Applicant: YUKONG LIMITED [KR/KR]; 26-4, Yoido-dong, Yongdungpo-gu, Seoul 150-010 (KR).

(72) Inventors: LEE, Yun, Kil; Eunha Apartment A-909, 52, Yoido-dong, Yongdungpo-gu, Seoul 150-010 (KR). MIN, Wha, Sik; Shinsigaji Apartment 602-1201, Mok-dong, Yangchun-gu, Seoul 158-050 (KR). KWON, Sook, Hyung; 180-457, Bongchun-11-dong, Kwanak-gu, Seoul 151-050 (KR).

(74) Agents: LEE, Chul et al.; 824-38, Yeoksam-dong, Kangnam-gu, Seoul 135-080 (KR).

(54) Title: METHOD FOR PRODUCING FEEDSTOCKS OF HIGH QUALITY LUBE BASE OIL FROM UNCONVERTED OIL OF FUELS HYDROCRACKER OPERATING IN RECYCLE MODE



(57) Abstract

A process method to produce the feedstocks for manufacturing high quality lube base oil of the present invention is utilizing the unconverted oil (UCO), which is produced from a fuels hydrocracker unit, to manufacture the feedstock oils of high quality lube base oil with very high viscosity index and low volatility, in which a portion or all of the unconverted oil from the fuels hydrocracker unit is continuously fed to a second vacuum distillation process unit and the vacuum distillation unit will produce different grades of lube base oil feedstocks with desired viscosity ranges, while this vacuum distillation unit can effectively remove the undesirable polynuclear aromatics and heavy refractory hydrocarbons, which can accumulate in the recycle oil stream and can cause rapid decline in catalyst performance and degradation in product selectivity to the hydrocracker unit in recycle mode.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	**GB**	United Kingdom	**MR**	Mauritania
AU	Australia	**GE**	Georgia	**MW**	Malawi
BB	Barbados	**GN**	Guinea	**NE**	Niger
BE	Belgium	**GR**	Greece	**NL**	Netherlands
BF	Burkina Faso	**HU**	Hungary	**NO**	Norway
BG	Bulgaria	**IE**	Ireland	**NZ**	New Zealand
BJ	Benin	**IT**	Italy	**PL**	Poland
BR	Brazil	**JP**	Japan	**PT**	Portugal
BY	Belarus	**KE**	Kenya	**RO**	Romania
CA	Canada	**KG**	Kyrgystan	**RU**	Russian Federation
CF	Central African Republic	**KP**	Democratic People's Republic of Korea	**SD**	Sudan
CG	Congo			**SE**	Sweden
CH	Switzerland	**KR**	Republic of Korea	**SI**	Slovenia
CI	Côte d'Ivoire	**KZ**	Kazakhstan	**SK**	Slovakia
CM	Cameroon	**LI**	Liechtenstein	**SN**	Senegal
CN	China	**LK**	Sri Lanka	**TD**	Chad
CS	Czechoslovakia	**LU**	Luxembourg	**TG**	Togo
CZ	Czech Republic	**LV**	Latvia	**TJ**	Tajikistan
DE	Germany	**MC**	Monaco	**TT**	Trinidad and Tobago
DK	Denmark	**MD**	Republic of Moldova	**UA**	Ukraine
ES	Spain	**MG**	Madagascar	**US**	United States of America
FI	Finland	**ML**	Mali	**UZ**	Uzbekistan
FR	France	**MN**	Mongolia	**VN**	Viet Nam
GA	Gabon				

METHOD FOR PRODUCING FEEDSTOCKS OF HIGH QUALITY LUBE BASE OIL FROM UNCONVERTED OIL OF FUELS HYDROCRACKER OPERATING IN RECYCLE MODE

BACKGROUND OF THE INVENTION

Field of the invention

The present invention relates to a method for producing feedstocks of high quality lube base oil from unconverted oil and, more particularly, to an improvement in efficiency along with a method for continuous production of high quality lube base oil from unconverted oil produced by a fuels hydrocracker in recycle mode.

Description of the Prior Art

In general, a fuels hydrocracker is a process for converting vacuum gas oil (VGO) produced from a vacuum distillation unit (V1) into fuel grade hydrocarbons such as diesel (as shown in Figure 1). The VGO feed contains a large amount of impurities such as sulfur, nitrogen, oxygen, metals and other materials not only harmful to the catalyst system but also undesirable in the products. Such impurities are removed in the hydrotreating reaction unit (R1) and the resulting hydrotreated VGO undergoes hydrocracking in the main reactor (R2) to convert a major part of it into light hydrocarbons. The reactor effluents are first separated into hydrogen-rich gas and hydrocarbon liquid, the hydrogen rich gas is recycled back to above two reactors (R1 and R2) and the hydrocarbon liquid is fractionated into several different grades of petroleum products in a series of fractionators (Fs). Since it is essentially impossible to accomplish 100% conversion in the reaction, a portion of the feed not converted to diesel and lighter products ends up as the final fractionator bottom stream.

In fact, fuels hydrocrackers are normally designed such that the per-pass conversion (conversion achieved by a

single passage through the hydrocracking reactor) is around 60%. The unconverted oil (UCO) is then either sent to storage as a semi-final product (this type of operation is called "once-through mode") or recycled back to the main reactor (R2) for further cracking to increase the overall conversion(this type of operation is called "recycle mode").

Being a mixture of highly saturated hydrocarbons, the UCO has many desirable characteristics such as high viscosity index, which is one of the most important properties for lube base oil. Table 1 shows typical properties of VGO and UCO for overall conversion of 85% and per-pass conversion of 60%.

Table 1

The Properties of the VGO and the UCO

Properties	VGO	UCO
API Gravity	22	38
Distillation[‡] °C		
- IBP[**] / 5%	260/340	350/370
- 10% / 20%	372/396	385/398
- 30% / 40%	415/434	410/422
- 50% / 60%	445/460	435/446
- 70% / 80%	475/492	458/474
- 90% / 95%	516/538	496/515
- FBP[***]/ %recovery	547/98.5	536/99.0
Hydrogen, wt%	12.0	15.0
Nitrogen, wppm	800	4.0
Sulfur, wt%	3.0	0.0009
Aniline point °C	78	118
Pour Point °C	33	38
Viscosity, cst		
@ 40 °C	49.9	19.3
@ 60 °C	19.4	10.7
@ 100 °C	6.35	4.4
Viscosity Index	64	143
Saturation Degree of Hydrocarbon, wt%	31	98

‡ ASTM D-1160, @ 760 mmHg ** Initial Boiling Point
*** Final Boiling Point

From the economic standpoint, it is more advantageous to utilize the UCO for high quality lube base oil after further processing such as dewaxing and stabilization than use it as fuel oil blending stock or recycle it to the hydrocracking reactor. Some refineries are known to be producing lube base oil with very high viscosity index using the UCO generated from a fuels hydrocracker. For example, a refinery produces VHVI(Very High Viscosity Index) lube base oil at their lube base oil plant utilizing the UCO from their fuels hydrocracker with once-through mode. The hydrocracker plant is located far away from the lube base oil plant.

However, the above conventional method for manufacturing lube base oil from the UCO in that plant has several problems. The UCO generated from the fuels hydrocracker is fed to the lube base oil plant. In that process, several existing units are being utilized including a vacuum distillation unit, a solvent extraction unit, a solvent dewaxing unit and so on in a "blocked mode" and becomes quite cumbersome with rather low operation efficiency.

For the above-mentioned plant, it becomes especially so, because the existing vacuum distillation unit was originally designed for processing atmospheric residue (AR). It is even necessary to blend the UCO with heavier stocks such as vacuum residue (VR) before feeding it to the existing vacuum distillation unit. For a better understanding of the background of the present invention, the description for a typical fuels hydrocracker in recycle mode is given below. And refer to the enclosed Figure 1.

Atmospheric residue (AR) is fed into the first vacuum distillation unit (V1) to produce a vacuum gas oil (VGO). The VGO is then hydrotreated in the first reactor (R1) for the removal of impurities such as sulfur, nitrogen, oxygen and metals. The resulting treated VGO is then hydrocracked to yield a variety of hydrocarbon products in the second reactor (R2). These hydrocarbons are separated in a series

of fractionators (Fs) to produce various light oil products and diesel oil.

However, not all of the cracked hydrocarbons are converted into diesel and lighter products. A substantial portion of the hydrocarbons remains unconverted. Most of such unconverted oil is sent back to the second reaction unit (R2) for further conversion. With high-endpoint vacuum gas oil feedstocks, however, heavy refractory hydrocarbons and condensed polynuclear aromatic compounds could gradually accumulate in the fuels hydrocracker's internal recycle oil stream. Excessive concentration of those compounds can cause rapid decline in catalyst performance and degradation in product selectivity. In order to avoid such operational instability, a small bleed stream of unconverted oil becomes necessary to purge those compounds from the system and to maintain a suitable level of reaction activity. For that purpose, in general, the fuels hydrocracker in recycle mode recycles a small portion of the product fractionator bottoms back to the feed vacuum column (V1).

The purpose of such a recirculation scheme is to reject a portion of the refractory components and polynuclear aromatics to the vacuum residue. Such a scheme also minimizes the quantity of unconverted oil that must be purged from the product fractionator bottoms. The typical recirculation rate to the feed vacuum column is 15 to 25 liquid volume % of the total unconverted oil.

In addition, the unconverted oil from the fuels hydrocracker with high conversion has an average viscosity ranging from 4.0 to 4.5 cst at 100°C, which is too low to make 150 Neutral lube base oil. The 150 Neutral lube base oil is one of the grades with high demand and has viscosities ranging from 5.5 to 6.0 cst at 100°C. Consequently, a considerable amount of the unconverted oil at most of the existing refineries as stated above is not being utilized for lube oil production, and wasted typically in the form of fuel oil.

SUMMARY OF THE INVENTION

Therefore, the objectives of the present invention is to solve the above problems encountered in the prior arts and to provide a method for producing feedstocks of high quality lube base oil. The present invention will make it possible to use the desired portion of the unconverted oil efficiently during the operation of the fuels hydrocracker in recycle mode, thereby utilizing the facilities to the maximum.

And this invention is the first such approach to produce continuously feedstocks of high quality lube base oil with very high viscosity index and low volatility from the fuels hydrocracker in recycle mode.

In accordance with the first embodiment of the present invention(as shown in Figure 2A), the above objective can be accomplished by providing a method for producing feedstocks of high quality lube base oil, comprising the steps of distilling an atmospheric residue (AR) under vacuum in a first vacuum distillation unit (V1) to give a vacuum gas oil (VGO); hydrotreating the vacuum gas oil in a first reaction unit (R1) to remove impurities therefrom; hydrocracking the treated vacuum gas oil in a second reaction unit(R2) to yield light hydrocarbons; applying a series of fractional distillations (Fs) to separate light oil products and an unconverted oil; feeding said unconverted oil to a second vacuum distillation unit (V2) to produce feedstocks of high quality lube base oil, having desired viscosities; and recycling the remaining portion of unconverted oil from the second vacuum distillation unit (V2) to the second reaction unit (R2).

In accordance with the second embodiment of the present invention(as shown in Figure 2B), the above objective can be also accomplished by providing a method for producing feedstocks of high quality lube base oil, comprising the steps of: distilling an atmospheric residue (AR) under vacuum in a first vacuum distillation unit (V1) to give a

vacuum gas oil (VGO); hydrotreating the vacuum gas oil in a first reaction unit (R1) to remove impurities therefrom; hydrocracking the treated vacuum gas oil in a second reaction unit (R2) to yield light hydrocarbons; applying a series of fractional distillations (Fs) to separate light oil products and an unconverted oil; feeding only a part of said unconverted oil to a second vacuum distillation unit (V2) to produce feedstocks of high quality lube base oil, having desired viscosities; and recycling the remaining portion of unconverted oil from the second vacuum distillation unit (V2) to the second reaction unit (R2), while recycling remainder of unconverted oil from said fractional distillations(Fs) to said second reaction unit(R2).

BRIEF DESCRIPTION OF THE DRAWINGS

Other objectives and aspects of the invention will become apparent from the following description of embodiments with reference to the following description of embodiments with reference to the accompanying drawings in which:

Fig. 1 is a block diagram illustrating a conventional fuels hydrocracker in recycle mode;

Fig. 2A is a block diagram illustrating a fuels hydrocracker and a method for producing feedstocks of high quality lube base oil according to the first embodiment of the present invention; and

Fig. 2B is a block diagram illustrating a fuels hydrocracker and a method for producing feedstocks of high quality lube base oil according to the second embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Hereinafter, the preferred embodiments of the present invention will be, in detail, described with reference to

the drawings above.

Fig. 2A illustrates a fuels hydrocracker and a method for producing feedstocks of high quality lube base oil according to the first embodiment of the present invention.

As illustrated in Fig. 2A, an atmospheric residue (AR) is fed into a first vacuum distillation unit (V1) to give a vacuum gas oil which is subsequently subjected to the treatment of hydrogenation in a first reaction unit (R1).

The hydrogenating reaction proceeds, removing impurities, such as sulfur, nitrogen, oxygen and metals, from the VGO. The resulting treated vacuum gas oil enters a second reaction unit (R2) wherein the treated vacuum gas oil is hydrocracked to yield a variety of light hydrocarbons. These hydrocarbons are separated in a series of fractional distillation steps (Fs), to produce various light oil products including diesel oil.

In the meanwhile, a substantial quantity of feed hydrocarbons remains unconverted. All of this unconverted oil is sent to a second vacuum distillation unit (V2) wherein the UCO is distilled to produce feedstocks of high quality lube base oil in accordance with the first embodiment of the present invention. While the oils with desired viscosities are fractionated from the UCO in the second vacuum distillation unit (V2) and subsequently subjected to dewaxing and stabilization so as to produce the lube base oil, the remaining part of the UCO is sent back to the second reaction unit (R2).

Fig. 2B illustrates a fuels hydrocracker and a method for producing feedstocks of high quality lube base oil according to the second embodiment of the present invention. As shown in this figure, a part of the UCO is taken to the second vacuum distillation unit (V2), whereas the other part is sent back to the second reaction unit (R2).

In accordance with the present invention, the additional vacuum distillation unit (V2) operating under vacuum is provided, wherein feedstocks of high quality lube base oil with appropriate viscosity grades can be produced.

For example, 150 Neutral, a viscosity grade in high demand and 100 Neutral which has viscosities ranging from about 3.8 to about 4.2 cst at 100°C can be produced as required.

It is preferable to operate the second vacuum distillation tower (V2) at temperature ranging from about 300 to about 380°C and pressure ranging from about 20 to about 300 mmHg at the tower bottom, according to the present invention.

Turning now to Fig. 1 of prior art, the amount of the UCO that is recycled to the second reaction unit (R2) is approximately 60 to 70% of the VGO feed. Approximately 75 to 85% of the UCO (approximately 50 to 56.7% of the VGO) is sent back to the second reaction unit (R2) through line 2, and approximately 15 to 25% of it (approximately 10 to 16.7% of the VGO) is sent back to the first vacuum distillation unit (V1) through line 1.

All or a part of the UCO proceed to the second vacuum distillation unit (V2) in accordance with the present invention, wherein it is fractionated to feedstocks of high quality lube base oil with desired viscosities. The lube base oil feedstock is approximately 15 to 25% of total UCO, which is equal to the amount sent back to the first vacuum distillation unit (V1) in the conventional process (Figure 1). The rest, which is approximately 75 to 85% of total UCO, is recycled to the second reaction unit (R2).

According to the present invention, the ratio of total UCO from the fractional distillation step (Fs) to the UCO recycled to the second reaction unit (R2) is preferably on the order of 1.05 to 2.0 : 1.

In accordance with the present invention, the ratio of the UCO proceeding to the second vacuum distillation unit (V2) to the UCO recycled to the second reaction unit (R2) from the second vacuum distillation unit (V2) is preferably on the order of 1.05 to 4.0 : 1.

As described above, it is unnecessary to send the UCO back to the first vacuum distillation unit (V1) in the present invention. This invention is the first approach to

utilize the UCO for manufacturing high quality lube base oil with very high viscosity index and low volatility continuously from the fuels hydrocracker while recycling the unused portion of the UCO back to the hydrocracking reaction unit.

The preferred embodiment of the present invention will now be further described with reference to specific examples.

EXAMPLE 1

A vacuum gas oil with the properties shown in Table 1 was processed in a hydrotreating reaction unit (R1) with a liquid hourly space velocity of 2.10 hr^{-1} and treated with a catalyst, commercially available from Nippon Ketjen Company in Japan, model HC-K, at reactor average bed temperature of 386.1°C and reactor inlet pressure of 2,523 psig, using a hydrogen rate of 5,720 SCF/BBL of reactor feed.

Thereafter, the resulting vacuum gas oil along with the unconverted oil to be described later was processed in a hydrocracking reaction unit (R2) with a liquid hourly space velocity of 1.26 hr^{-1} and treated with a catalyst, commercially available from UOP Incorporated in USA, model HC-22, at reactor average bed temperature of 393.8°C and reactor inlet pressure of 2,500 psig, using a hydrogen rate of 7,520 SCF/BBL of reactor feed.

Subsequently, all of the treated oil was subjected to a series of separations and fractional distillation steps (Fs) as shown in Fig. 2A, to obtain diesel and lighter products, and to give the 380°C + unconverted oil with the properties shown in the Table 1.

All of the unconverted oil was charged to a vacuum distillation unit (V2) wherein a tower top temperature, a tower bottom temperature, a tower top pressure and a tower bottom pressure are 80°C, 325°C, 75mmHg and 150mmHg, respectively and distilled, so as to give a light distillate(i) 33.0 LV%, an 100N distillate(ii) 8.3 LV%, a

middle distillate(iii) 11.7 LV% and a tower bottom product(iv), 150N light distillate 47.0 LV%.

From the above distillates, the 100N and the 150N distillates amounting to 25% of the unconverted oil fed to the vacuum distillation unit (V2), i.e. 100N; 5% and 150N; 20%, were drawn out, and the rest was mixed and recycled to the hydrocracking reaction unit (R2).

The properties of the distillates are shown in the following Table 2A.

EXAMPLE 2

A vacuum gas oil with the properties shown in Table 1 was processed in a hydrotreating reaction unit (R1) with a liquid hourly space velocity of 2.10 hr^{-1} and treated with a catalyst, commercially available from Nippon Ketjen Company in Japan, model HC-K, at reactor average bed temperature of 385.9 °C and reactor inlet pressure of 2,523 psig, using a hydrogen rate of 5,710 SCF/BBL of reactor feed.

Thereafter, the resulting vacuum gas oil along with unconverted oil to be described later was processed in a hydrocracking reaction unit (R2) with a liquid hourly space velocity of 1.25 hr^{-1} and treated with a catalyst, commercially available from UOP Incorporated in USA, model HC-22, at reactor average bed temperature of 384.1°C and reactor inlet pressure of 2,500 psig, using a hydrogen rate of 7,500 SCF/BBL of reactor feed.

Subsequently, the treated oil was subjected to a series of separations and fractional distillation steps (Fs) as shown in Fig. 2B, to obtain diesel and lighter products and to give the 380°C + unconverted oil with the properties shown in Table 1.

A half(50%) of the unconverted oil was recycled to the hydrocracking reaction unit (R2) and the other half(50%) was charged to a vacuum distillation unit (V2) wherein a tower top temperature, a tower bottom temperature, a tower top pressure and a tower bottom pressure are 80°C, 325°C, 75mmHg

and 150mmHg, respectively and was distilled so as to give a light distillate(i) 32.9 LV%, an 100N distillate(ii) 8.4 LV%, a middle distillate(iii) 11.8 LV% and a tower bottom product, 150N distillate(iv) 46.9 LV%.

From the above distillates, the 100N and the 150N distillates amounting to 50% of the unconverted oil fed to the vacuum distillation unit (V2), i.e. 100N : 10% and 150N : 40%, were drawn-out, and the rest was mixed and recycled to the hydrocracking unit (R2).

The properties of the distillates are shown in the following Table 2B.

Table 2A

The Properties of the Products from UCO Vacuum Distillation Unit(V2) (for Example 1)

Properties	Light Distil.	100 N Distil.	Middle Distil.	150 N Distil.
API Gravity	38.8	38.6	38.4	37.8
Distillation‡ °C				
- IBP‡‡ / 5 LV%	278/289	377/405	341/408	424/437
- 10% / 30%	305/402	406/412	410/424	442/458
- 50% / 70%	405/414	421/431	434/447	471/493
- 90% / 95%	430/437	446/453	469/483	514/519
- FBP‡‡‡	462	482	520	523
Viscosity, cst				
@ 60 °C	7.63	8.50	9.26	13.89
@ 100 °C	3.45	3.80	4.19	5.70
Viscosity Index	143	154	179	172
Flash Point(COC) °C	143	220	192	248
Noack Volatility, %		14.9		4.8
Average Molecular Weight	347	387	403	456
Watson K Value	12.73	12.88	12.93	13.04
Pour Point, °C		30.7		35.0

‡ ASTM D-1160, @ 760 mmHg, °C, Distil. : Distillate
‡‡ Initial Boiling Point ‡‡‡ Final Boiling Point

Table 2B

The Properties of the Products from UCO Vacuum Distillation Unit(V2)(for Example 2)

Properties	Light Distil.	100 N Distil.	Middle Distil.	150 N Distil.
API Gravity	38.9	38.6	38.3	37.8
Distillation* °C				
- IBP** / 5 LV%	275/288	378/404	339/407	425/438
- 10% / 30%	306/402	406/413	411/424	442/457
- 50% / 70%	404/413	420/431	433/446	476/495
- 90% / 95%	431/437	444/453	467/483	516/521
- FBP***	463	484	518	525
Viscosity, cst				
@ 60 °C	7.62	8.50	9.27	13.89
@ 100 °C	3.43	3.80	4.14	5.70
Viscosity Index	139	154	169	172
Flash Point(COC) °C	142	221	195	249
Noack Volatility, %		15.0		5.0
Average Molecular Weight	346	388	402	457
Watson K Value	12.72	12.88	12.92	13.04
Pour Point, °C		30.9		36.1

* ASTM D-1160, @ 760 mmHg, °C, Distil. : Distillate
** Initial Boiling Point
*** Final Boiling Point

As apparent from the above Examples and Tables, it is possible to produce feedstocks of high quality lube base oil of 100N and 150N showing very high viscosity index and low volatility in accordance with the present invention.

In addition, withdrawing part of the UCO prevents the accumulation of heavy refractory hydrocarbons and condensed polynuclear aromatic compounds and frees capacity in the

vacuum distillation unit (V1) and hydrotreating reaction unit (R1), allowing treatment of the vacuum gas oil in the same amount as the withdrawn lube base oil feedstock. Therefore, it has been proved that the present invention could utilize the facilities very efficiently.

Although the preferred embodiment of the present invention has been disclosed for illustrative purpose, those skilled in the art will appreciate that various modifications, addition and substitutions are possible, without departing from the scope and spirit of the present invention as disclosed in the accompanying claims.

WHAT IS CLAIMED IS ;

1. A method for producing feedstocks of high quality lube base oil utilizing the unconverted oil of fuel hydrocracker, comprising the steps of:

distilling an atmospheric residue under vacuum in a first vacuum distillation unit (V1) to give a vacuum gas oil;

hydrotreating the vacuum gas oil in a first reaction unit (R1) to remove impurities therefrom;

hydrocracking the treated vacuum gas oil in a second reaction unit (R2) to yield light hydrocarbons;

applying a series of fractional distillations (Fs) to separate light oil products and an unconverted oil;

feeding all of said unconverted oil to a second vacuum distillation unit (V2) to produce feedstocks of high quality lube base oil, having desired viscosities; and

recycling the remaining portion of unconverted oil from the second vacuum distillation unit (V2) to the second reaction unit (R2).

2. A method according to Claim 1, wherein the lube base oil feedstocks having a desired viscosity range are subjected to further dewaxing and stabilization process, while recycling the remaining portion of unconverted oil from the second vacuum distillation unit (V2) to the second reaction unit (R2).

3. A method according to Claim 1, wherein the second vacuum distillation unit (V2) is operated at tower bottom temperature ranging from about 300 to about 380°C under tower bottom pressures ranging from about 20 to about 300mmHg.

4. A method according to Claim 1, wherein the ratio of total unconverted oil from the fractional distillations (Fs) to the unconverted oil recycled to the second reaction unit

(R2) is on the order of 1.05 to 2.0 : 1.

5. A method according to Claim 1, wherein the ratio of the unconverted oil sent to the second vacuum distillation unit (V2) to the unconverted oil recycled to the second reaction unit (R2) from the second vacuum distillation unit (V2) is on the order of 1.05 to 4.0 : 1.

6. A method for producing the feedstocks of high quality lube base oil, comprising the steps of;

distilling an atmospheric residue (AR) under vacuum in a first vacuum distillation unit (V1) to give a vacuum gas oil (VGO);

hydrotreating the vacuum gas oil in a first reaction unit (R1) to remove impurities therefrom;

hydrocracking the treated vacuum gas oil in a second reaction unit (R2) to yield light hydrocarbons;

applying a series of fractional distillations (Fs) to separate light oil products and an unconverted oil;

feeding only a part of said unconverted oil to a second vacuum distillation unit (V2) to produce feedstocks of high quality lube base oil, having desired viscosities; and

recycling the remaining portion of unconverted oil from second vacuum distillation unit (V2) to the second reaction unit (R2), while recycling remainder of unconverted oil from said fractional distillations(Fs) to said second reaction unit(R2).

7. A method according to Claim 6, wherein the lube base oil feedstocks having a desired viscosity range are subjected to further dewaxing and stabilization process, while recycling the remaining portion of unconverted oil from the second vacuum distillation unit (V2) to the second reaction unit (R2).

8. A method according to Claim 6, wherein the second vacuum distillation unit (V2) is operated at tower bottom

temperature ranging from about 300 to about 380°C under tower bottom pressures ranging from about 20 to about 300 mmHg.

9. A method according to Claim 6, wherein the ratio of total unconverted oil from the fractional distillations (Fs) to the unconverted oil recycled to the second reaction unit (R2) is on the order of 1.05 to 2.0 : 1.

10. A method according to Claim 6, wherein the ratio of the unconverted oil sent to the second vacuum distillation unit (V2) to the unconverted oil recycled to the second reaction unit (R2) from the second vacuum distillation unit (V2) is on the order of 1.05 to 4.0 : 1.

Fig. 1

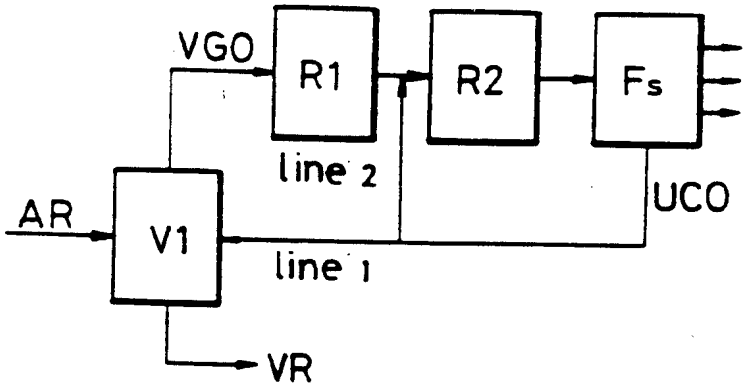

VGO
R1
R2
Fs
line 2
UCO
AR
V1
line 1
VR

Fig. 2A

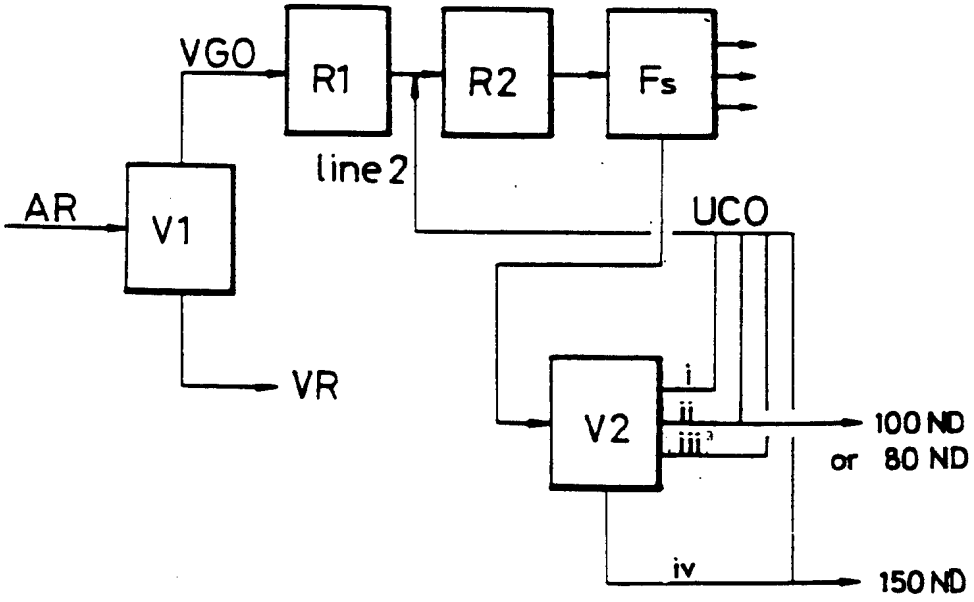
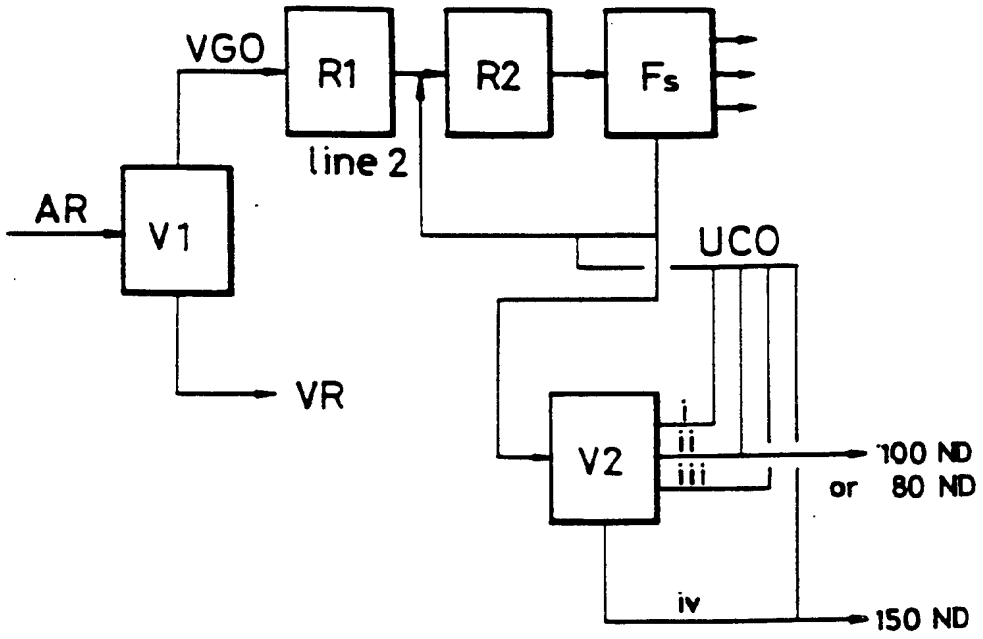

VGO
R1
R2
Fs
line 2
AR
V1
UCO
VR
V2
i
ii
iii
100 ND
or 80 ND
iv
150 ND

Fig. 2B



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR 94/00046

A. CLASSIFICATION OF SUBJECT MATTER

IPC[5]: C 10 G 65/12, 69/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC[5]: C 10 G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPIL

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 4 983 273 (MOBIL OIL CORPORATION) 08 January 1991 (08.01.91), claims 1,8; column 1, lines 15-25	1,6

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 July 1994 (28.07.94)	22 August 1994 (22.08.94)
Name and mailing address of the ISA/ AT AUSTRIAN PATENT OFFICE Kohlmarkt 8-10 A-1014 Vienna Facsimile No. 1/53424/535	Authorized officer Böhm e.h. Telephone No. 1/53424/226

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR 94/00046

Im Recherchenbericht angeführtes Patentdokument Patent document cited in search report Document de brevet cité dans le rapport de recherche	Datum der Veröffentlichung Publication date Date de publication	Mitglied(er) der Patentfamilie Patent family member(s) Membre(s) de la famille de brevets	Datum der Veröffentlichung Publication date Date de publication
US A 4983273	08-01-91	AU A1 63783/90 AU B2 639027	11-04-91 15-07-93